Test report

Basalt fiber testing and evaluation

Tamás Deák

Ph.D. student
Budapest University of Technology and Economics
Faculty of Mechanical Engineering
Department of Polymer Engineering
H-1111 Budapest
Muegyetem rkp. 3. T. bld. III. 36.
Hungary
e-mail: deak@pt.bme.hu
web: www.pt.bme.hu

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1. Current state of the research

My objective is the assessment of the usability of continuous basalt fibers as the reinforcement of injection molded thermoplastic composites. Our department has already done successful efforts to produce such composites using short basalt fibers made by a special melt spinning technology in Hungary. Several different commercial products have been created using this material, mostly replacing glassfiber reinforced compounds. These fibers have relatively moderate mechanical properties, but they are very cheap, which makes them remunerative even if they are applied in greater proportion than the glassfibers. Fig. 1. shows a percussion hand drill housing manufactured from 45wt% basalt fiber reinforced PA 6.

The next stage is the adaptation of continuous basalt fibers and finding possible benefits and application fields which make this composite competitive with the pervading glassfiber-based compounds. We chose polyamide 6 as matrix material, because the glass fiber reinforced, injection molded PA is a widely used polymer composite, especially in the electric and automotive industry. Different PA materials reinforced with up to 50wt% glass fibers are widely used for manufacturing high performance products. The continuous basalt fibers could substitute the glass fibers for these applications. On the other hand, the polar molecular structure of the PA probably makes the promotion of the matrix-fiber adhesion easier.

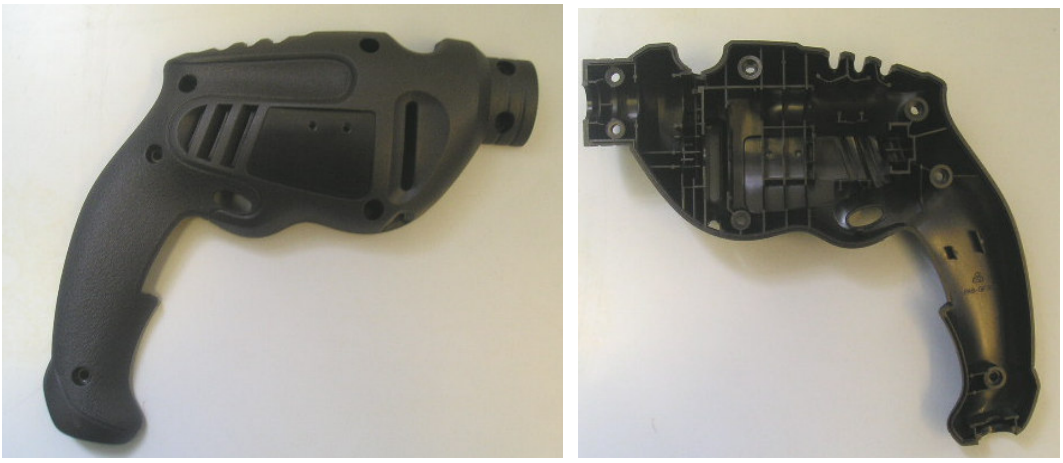


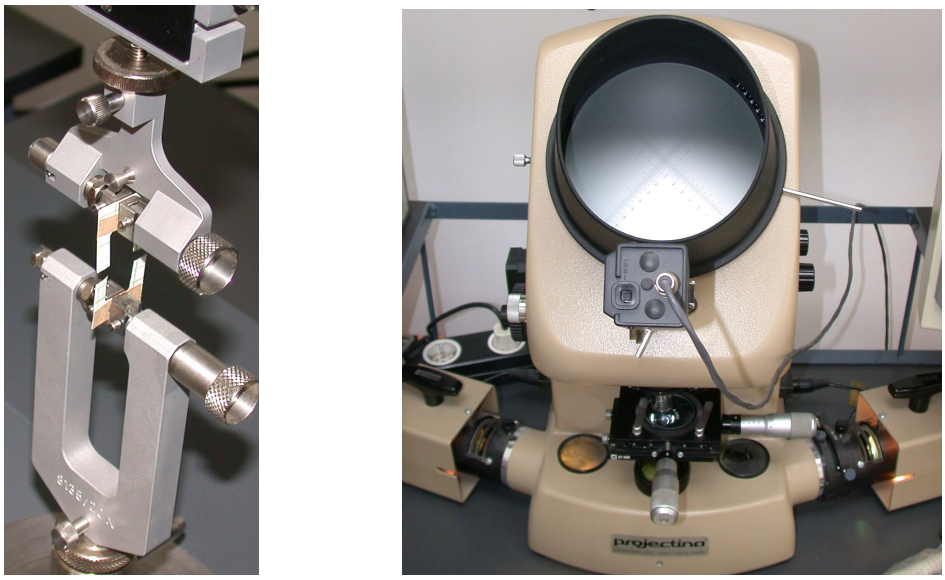
Fig. 1. Injection molded percussion hand drill housing made from basalt fiber reinforced polyamide 6

2. Fiber tests

Since the fibers are very short in injection molded composites (on the average from 0.2 to 0.4 mm), the key issue of development is the interaction between the matrix and the fibers. Because of this, the development emphasizes the interfacial aspects. At first we are investigating the properties of the fiber and basic composites with the original (applied by the fiber producer) sizing. The first stage was the determination of the mechanical properties of the fibers.

Method

The tensile tests of the fibers were carried out using a Zwick Z002 testing machine and a special grip (Fig. 2/a.). The gauge length was 25 mm and the test speed was 2 mm/min. The elementary fibers retrieved from the roving were stuck to paper windows (Fig. 3.) and their diameter was measured on a Projectina 4014/BK-2 optical microscope (Fig. 2/b.). Subsequently the specimens were clamped to the testing machine, the paper window was cut and the fiber was torn.



a b

Fig. 2. Special grip of the Zwick Z002 testing machine (a) and Projectina 4014/BK-2 optical microscope (b)

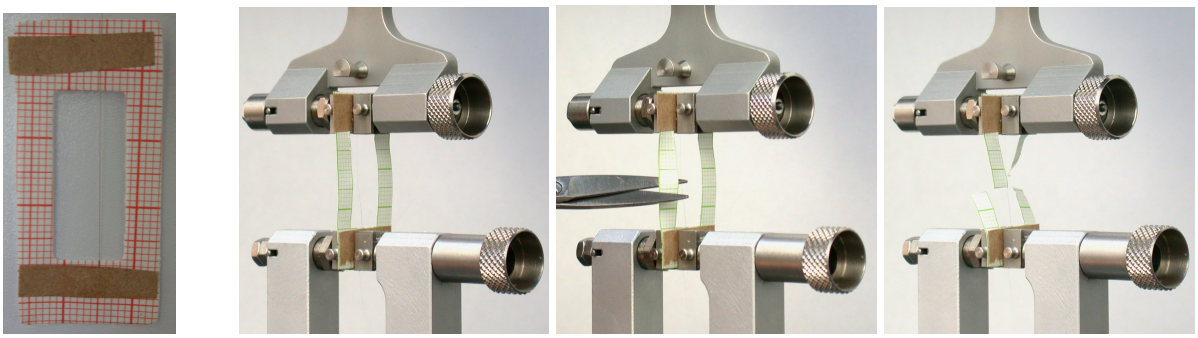


Fig. 3. Tensile test of basalt fibers with 25 mm gauge length, using paper windows

During the test 100 fibers were tested and the the following values were measured: fiber diameter (d_f), fiber cross section area (A_f), maximum force (F_{max}), extension at failure (Δl_{max}), specific elongation at failure (ε), tensile strength (σ_{max}) and Young modulus (E). The results can be seen in Table 1. The elongation and the Young modulus were calculated from the travel of the testing machine's crosshead. The standard deviations also were calculated for each value.

Value	diameter	cross section	maximum force	extension at failure	specific elongation	tensile strength	Young modulus
	d_f	A_f	F_{max}	Δl_{max}	ε	σ_{max}	E
Unit	µm	μm^2	N	mm	%	MPa	GPa
Average	14.2	160.2	0.32	0.89	3.56	2016	61.9
Standard deviation	1.4	30.3	0.09	0.22	0.89	434	3.5

Table 1. Results of the basalt fiber tensile tests

Table 2. shows the comparison of the basalt fiber and two different E glass fibers, measured with the same parameters as the basalt fibers.

Value	diameter	maximum force	specific elongation	tensile strength	Young modulus
	d_f	F_{max}	ε	σ_{max}	E
Unit	µm	N	%	MPa	GPa
Basaltfiber	14.2±1.4	0.32±0.09	3.56±0.89	2016±434	61.9±3.5
E-glass (1)	14.0±1.4	0.23±0.07	3.10±1.18	1490±339	52.2±18.2
E-glass (2)	18.3±1.1	0.49±0.09	3.26±0.67	1868±305	60.3±2.3

Table 2. Comparison of basalt fiber and E glass fibers

3. Future plans

In the next few months the following additional tests will be executed on the fibers:

- I am intended to develop a more accurate test method for measuring the tensile strength of the elementary fibers, with smaller (1 to 5 mm) gauge length.
- Investigation of the chemiacal composition of the fibers.
- Investigating the effect of processing conditions (high temperature) on the properties of the fibers.
- Technology trials (compounding and injection molding) in order to determine the properties and technology aspects of basalt fiber reinforced composites (e.g. fiber shortening, orientation, interfacial strength) compared to glassfiber reinforced composites.